Paper Code: ALRT2052

Team Resilience in Emergency Response: Analytical Framework and Study of Air Transport Accident Reports

Levashini Gunasegar[a], Oanh Nguyen[b], Natalia Nikolova[c,d], Kiril Tenekedjiev[e,f]

[a] Australian Maritime College, University of Tasmania, 1 Maritime way, 7250, Launceston, TAS, Australia. Email: lg5@utas.edu.au
[b] Australian Maritime College, University of Tasmania, 1 Maritime way, 7250, Launceston, TAS, Australia. Email: o.nguyen@utas.edu.au
[c] Australian Maritime College, University of Tasmania, 1 Maritime way, 7250, Launceston, TAS, Australia. E-mail: Natalia.Nikolova@utas.edu.au
[d] Nikola Vaptsarov Naval Academy – Varna, 73 V. Drumev Str., 9026 Varna, Bulgaria.
[e] Australian Maritime College, University of Tasmania, 1 Maritime way, 7250, Launceston, TAS, Australia. E-mail: Kiril.Tenekedjiev@utas.edu.au
[f] Nikola Vaptsarov Naval Academy – Varna, 73 V. Drumev Str., 9026 Varna, Bulgaria.

Abstract

Objective: Emergency response and resilience are critical to air transport due to their role in ensuring the safety of people and assets. In most accidents, the performance of the cockpit team plays a significant role in restoring the operations or minimizing the loss. The team resilience in the transport sector as a whole is understudied. We seeks to identify the influential factors in cockpit team resilience and analyze their effect on team performance in air transport emergency and crisis.
Design/methodology/approach: A team resilience analysis framework is utilized, adopted from other resilience studies. The OODA LOOP model is applied to evaluate the team performance in emergency situations in three recent air transport accidents.
Findings: The analysis found that team communication and coordination were among the key issues to emergency response. This is traced back to cockpit resource management training and its effectiveness in improving onboard team performance and leadership. The effect of team-related factors such as unity and culture, on team resilience is also highlighted.

Keywords: OODA LOOP, organizational management; transport management; cockpit resource management

1. Introduction

The air transportation sector is a multifaceted sociotechnical system involving interaction of human operators and technical systems. The capability of air transportation to sustain operations by adjusting those in the face of a wide range of disturbances (e.g. delays, disaster, weather, aircraft malfunctions, etc.) is a vital feature. In spite of technological signs of progress in aviation and navigation like the introduction of the glass cockpits, or the developments of global aviation training (GAT), air transport accidents remain an issue. The last four years have seen continuous increase in the number of accidents (from 2.15 to 2.73 accidents per million departures according to the International Civil Aviation Organization).Aviation accidents relate to loss of life and assets, thus instigating social and economic losses, as well as reputational damage (to companies and the sector). Therefore the study of team resilience and its potential to lower accidents is significant.

In the past 5-10 years there were more studies on the resilience of workforce in the workplace. Team resilience has been explored in more detail around sports science (see Morgan *et al.* (2015); Gorgulu *et al.* (2018), engineering see Chialastri and Pozzi (2008), health care Sommer *et al.* (2016); McCray *et al.* (2016), military training Mjelde *et al.* (2016), organizational behaviour Johansson *et al.* (2018); King *et al.* (2016), etc. Those studies are mainly in the non-aviation sector, while the transport (and specifically the aviation) sector are understudies.

Although procedures and regulations tend to specify the working process in aviation to a considerable extent, the flexibility and system oversight of pilots and crew onboard are essential for efficient and safe operations in normal and non-normal conditions. The capability of the onboard crew to subsist accidents is crucial especially when the obstacle and the undesirable impact are high, difficult to control, and need instant reaction with no time to plan an adequate response. Hence, teamwork is necessary for the onboard crew because not only teams bring synergy, but aircraft operations require management and good communication between crew members to complete team tasks. Teamwork also helps crews adjust to rapidly changing processes and highly automated systems and juggle conflicting goals to ensure and safe, efficient and environmentally friendly operations.

The need for the global aviation sector to develop resilience guidelines in emergency situations is gaining momentum. However, trivial consideration is given to developing the resilience of the onboard team. Few studies deal with team resilience and emergency response (e.g. Morgan *et al.* 2013). Current research tends to prioritize factors like leadership, organization, interaction, and safety culture that are vital to the performance of a team. For instances, team resilience and team performance depend on interaction and organisation. Interaction and organisations are mainly influenced by monitoring of activities, attention redirection to perceived priorities, an implicit delegation of responsibilities, as well as explicit verbal assignation of activities (see Lundberg and Johansson, 2015). This enhances team members onboard to have safe aeroplane operation.

Our paper reviews the role of team performance and resilience in emergency response in the aviation domain. Our aim is to assess the significant factors in team resilience and how team performance can be measured in aviation. We utilize earlier findings from team resilience study in the maritime domain (see Nguyen *et al.* 2019). We analyze several aviation accident reports and compare those against the team resilience factors to identify the gaps in accident study and develop quality performance assessments for onboard crew. We demonstrate the importance of cockpit resource management training for better onboard team performance. We also highlight the importance of unity and culture in team efficiency on board. In what follows, section 2 offers a review on team resilience. In section 3 we demonstrate the analytical framework that is later on applied to analyse three case studies related to air transport team resilience (section 4). Section 5 concludes the paper.

2. State-of-the-art in team resilience – an overview

2.1 Viewpoint to team resilience

By definition, a team is a group comprised of members with high task interdependency, shared goals and shared values Dyer (1984). They are usually organised hierarchically and sometimes dispersed geographically. An important characteristic of a team is that team members do not work in isolation. Instead, they work together, share information and coordinate to accomplish the team's objective. Unlike work carried out independently by individuals, teamwork requires interactions and interdependence between team members. Moreover, this helps to create social capital that offers the emotional bond and closeness between team members during difficult times Morgan *et al.* (2013).

One key attribute of teamwork is that it typically involves interaction with varying style and levels. The level of interaction can be important to team performance Stachowski *et al.* (2009). Yet, the interaction between team members and their performance also depends on other factors such as their relationship. There are two views on this. According to the first view, effective teams will engage highly consistently in an emergency or crisis. It can be argued that it would be impossible to train people for specific situations because crises are unique Yu *et al.* (2008). Therefore, it is important for the team to develop readiness and be prepared for unexpected situations. Similarly, teams that consistently maintain the established interaction norms and follow the same role structure may avoid the ambiguity of having to determine prioritisation and distribution of tasks Waller (2001).Those trained to be familiar to their prescribed roles and procedures are expected to behave more predictably and orderly Stachowski *et al.* (2009). According to the second view, routinized interaction patterns may inhibit flexibility and response in unexpected situations Hedlund *et al.* (1998). Pattern complexity could also affect team effectiveness Burgoon (1993) because teams that fail to adapt and adjust their interaction patterns may be less effective Gersick and Hackman (1990).

Team resilience refers to the capacity of a team to overcome crises and difficulties Morgan *et al.* (2017). It is the ability to "either thrive under high liability situations, improvise, and adapt to significant change or stress, or simply recover from the negative experience". However, team resilience differs from individual resilience in many ways Alliger *et al.* (2015). Overall, it is expected that the performance of a good team is better than the sum of its individuals. Team work's focus is on collectivism, not individualism. Team performance depends heavily on sharing, communication, coordination and leadership, while individual performance depends on different factors such as health and education Page (2008).

It has also been recognised that communication is a critical factor in team performance Stout *et al.* (2003) because it enables members to learn and support each other. Team learning and collective orientation are also important as they help team members to gain knowledge and collective intelligence and improve team performance Kim *et al.* (2017). Through the communicating and sharing of information and experience, team members can develop enhanced learning resourcefulness and behavioural preparedness in adverse circumstances Lengnick-Hall *et al*. (2011). Teams with a learning orientation are more likely to overcome challenges and be performing better in the long run. The team that has enhanced their competencies is more likely to register and deal with the complexity of dynamic decision milieus Sutcliffe and Vogus (2003).

The work Sauer *et al.* (2006) identified barriers against effective team communication, e.g. high workload, cultural difference and time that team members have come to know each other. Information sharing and shared cognition are important factors in team performance Entin and Serfaty (1999). To the opposite, an important factor of team resilience is diversity within the team. Teams that include at least some members with experientially wider skill may be better able to grasp variations in their circumstances. They are also better able to see specific changes that need to be made and may also be better at handling those changes Knapp (2010). At the same time, diversity increases the team’s access to resolving problems under challenging conditions. Diversity in a team can facilitate greater situational awareness, which contributes towards better decision-making and increased options for actions. This enhances the ability to handle complexity and increases their motivation and persistence in handling challenges using more effective strategies Chapman *et al.* (2020).

Leadership has also been found to be influential to team performance due to its extensive effect on the team including decision making, mental support, intellectual stimulation and influence. Inspirational influence helps the team leader to empower team members and promote the team’s internal strength to enable it to achieve its goals Jung *et al.* (1995). Intellectual stimulation promotes intelligence and problem-solving ability. Across different fields such as sports and competition, leadership helps stimulate the team and provides a proactive approach in challenging and difficult situations Rodríguez-Sánchez and Vera Perea (2015). Moreover, strong leadership can leverage team cohesion and enhance the team’s resilience to withstand stressors.

One aspect of leadership is transformational leadership. Transformational leaders empower teams to be more self-assured in their capability to deal with failure and inspire them to take risks. This will pursue innovative and ingenious events which promotes the levels of team resilience behaviour, which in turn may enhance the levels of team viability Dimas *et al.* (2018). Moreover, transformational leadership influences team resilience through the leader's frequent reinforcement of the team's strategic priorities. Kozlowski and Ilgen (2006) suggested that this process operates through perceptual filtering whereby people take in new information and interpret it, according to prior experiences, to reduce uncertainty about new experiences.

Another key factor influential to team performance is team coordination that ensures team members work toward the team’s objective and support each other Lundberg and Johansson (2015). In emergencies, the role of teams becomes more evident in reaching a successful outcome. Thus, the ability to operate as a coherent team increases the resilience of a given group Rodríguez-Sánchez and Vera Perea (2015).

2.2 Resilience in Air Transportation

Air transportation has perhaps the shortest history and the fastest revolution amongst all transport modes we use nowadays. Air transport offers the quickest means of moving people and cargo across geographical locations at varying distances. Its workplace is the whole world, so it deeply needs international rules to be enforced properly on an international scale.

Hence, international organizations and national authorities set up rules and guidelines regarding air transport nationally and internationally. However, aviation staff are essential to adjust to fast-changing methods and highly automated arrangements and misrepresent conflicting goals to ensure ever safe, competent and globally friendly processes (Hesse *et al.* 2013)

The aviation industry believes the introduction of resilience might be a helpful concept in improving safety management in order to have continuously safe and efficient operations (Hesse *et al.* 2013). Eurocontrol (2009) has provided the following meaning of resilience in air transportation: "*resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*".

Resilience in aviation pertain to four basic elements: anticipate, monitor, react and learn (Woltjer *et al.* 2015). Being able to anticipate developments further into the future refers to anticipating possible disturbances, new opportunity, and varying operation circumstances, etc. Monitoring means the capability of knowing what to search for, which could seriously affect the system's performance. Reacting is the ability to self-prepare for any situations that are occurring now or might occur in the future. Learning is the ability to obtain new knowledge from experience. These four basic elements enhance resilience in air transportation to withstand stressors (Owen *et al.* 2017).

Another factor in resilience air transport to ensure effective safety management is resilience safety culture. Resilience safety culture is defined as an organizational culture that persuades safe practices, reassures the method of dynamic and effective safety reporting Kozlowski and Ilgen (2006). Resilience safety culture is influenced by four properties in air transportation: learning culture, reporting culture, just culture and flexible culture. Learning from all relevant sources such as accident, flight data, risk analyses, etc. helps to improve safety organization in the air transportation field. Reporting culture is informing an incident that is occurring or might occur during a flight operation, which helps to reduce possible errors. The just culture assumes that nobody in the organization is punished or mistreated in any shape or form for omissions as long as their decisions are commensurate with their experiences and training and the context of the action is taken into Akselsson *et al.* (2009). The flexible culture is where skills, knowledge and abilities determine who takes the lead or performs a task in difficult situations such as emergencies and shifting back again when the problems are resolved Akselsson *et al.* (2009). Hence, continuous improvement is an important concept in resilience safety culture that needs to be implemented in future research.

While all those factors are being investigated in literature, the significance of team resilience in air transport remains an understudies area. The safety standards and procedures strongly focus on individual skillsets and capabilities of the flight crew, while putting a lesser focus on the team dimension of resilience, related to proper coordination, trust, leadership and interaction.

3. Description of the analytical framework for assessment of team resilience

There are four vital aspects acknowledged in literature when developing analytical frameworks to analyse team resilience: *Coordination* Amaral *et al.* (2015);

Sharing/cohesion/trust, Amaral *et al.* (2015); *Leadership* Morgan *et al.* (2013); *Communication/interaction* Gucciardi *et al.* (2018).

It is vital to take into account the emergency response method, where team resilience occurs and originates from, in order to identify the characteristics of resilience particularly in emergency response (Gucciardi *et al.*, 2018).There are several existing systemic resilience models developed as a factor of team resilience, none of which considered team resilience. Such is the case for the systematic resilience model proposed in Lundberg and Johansson (2015), which considers several elements, e.g. functional dependencies, constraints, the capability to regulate or acclimate, tactics (see Figure 1). The method is allocated into 5 categories, identified as '*Anticipate', 'Monitor', 'Control', 'Recover',* and *'Learn'* Nguyen *et al.* (2019).

As a substitute to the systematic resilience model, the 'OODA LOOP' was developed (Boyd, 1996). The OODA LOOP structure for the emergency response procedure includes the phases of *'Observe', 'Orient', 'Decide',* and *'Act'* Linthicum (2012). The OODA LOOP allows that 'implied guidance and control' procedure and 'nourish forward' process to exist simultaneously. The model of the procedure is proposed in Figure 2. The OODA LOOP includes no team factors which is why it is not applicable for teamwork, despite its popularity. That is why the work Nguyen et al. (2019). proposed an analytic framework for team resilience in emergency response that reflects the key team resilience characteristics and emergency response process. The model has possibilities for alteration and modification to adapt to various needs. For instance, the four-element in OODA LOOP - 'Observe', 'Orient', 'Decide', and 'Act' can be substituted with 'Respond', 'Engage', 'Act', 'Communicate' and 'Transition' from the REACT framework Linthicum (2012).

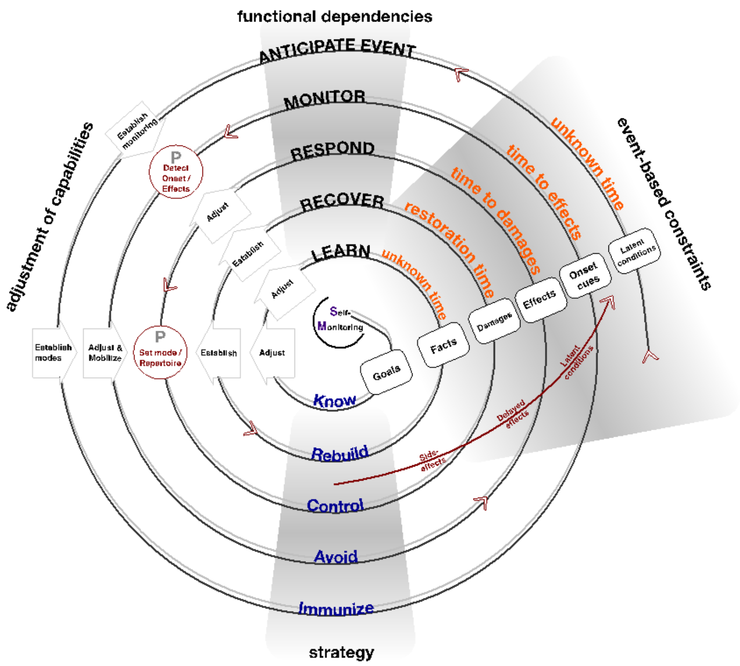

Figure 1: The Systemic Resilience Model (Lundberg and Johansson 2015).

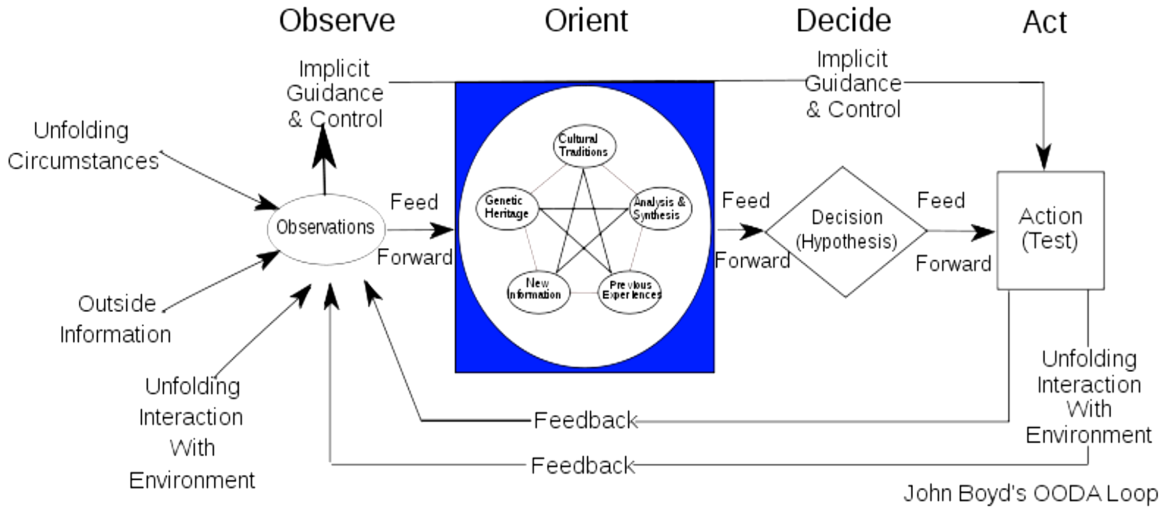

Figure 2: OODA LOOP (Boyd 1996).

4. Case study of team resilience in air transport

This section presents three case studies from aviation accidents and explores the role of team resilience. Each case study uses detailed accident reports. We employ the analytical framework from section 3 to integrate emergency response and teamwork.

The first dimension – emergency response – has four elements corresponding to the following four response stages of the OODA LOOP model developed in Boyd (1996) and Von Lubitz *et al.* (2008):

- *'Observe';*
- *'Orient';*
- *'Decide';* and
- *'Act'.*

The OODA LOOP model was chosen because of relevance to emergency response in air transport. It also allows for the co-presence of an 'implied guidance and control' technique and the 'nourish forward' method.

The second dimension – teamwork – includes four elements as per the literature review:

- *Coordination* Gomes *et al.* (2014); Amaral *et al.* (2015)
- *Sharing/cohesion/trust* Amaral *et al.* (2015); Stephens *et al.* (2013); Lionel (2015).
- *Leadership* Morgan *et al.* (2015); Dimas *et al.* (2018); Sommer *et al.* (2016); and
- *Communication/interaction* Gomes *et al.* (2014); Gucciardi *et al.* (2018); Lionel (2015).

As accident reports are essentially text documents, this analysis is essentially qualitative but can be extended to incorporate statistical analysis, thus allowing for mixed qualitative-quantitative analysis. The qualitative analysis is based on the coding with the themes derived from integrating the response and teamwork dimensions from the above integrated framework, for example, 'Sharing-Observe', 'Sharing-Orient', 'Sharing-Decide', 'Sharing-Act', 'Communication-Observe', 'Communication-Orien', etc. The results of contents analysis are then presented in a tabular form as a table in which each cell contains contents relevant to one theme of the above factors. Each cell also reports the number of counts for the corresponding theme, which are used for quantitative analysis. The quantitative analysis tests if there is any relationship between the two dimensions, i.e. whether teamwork has any role in emergency response process that was experienced by the team. Given the nature of data being nominal or categorical, non-parametric Chi-square tests are applicable with specifications given in Table 1.

Table 1: Hypothesis test of the relationship between team factors and response stages

Hypotheses: • H_0: There is no relationship between teamwork and emergency response process • H_1: There is a relationship between teamwork and emergency response process
Test statistic: $\chi^2 = \sum\left[\frac{(f_o - f_e)^2}{f_e}\right]$ f_o and f_e are observed and expected frequencies, and $f_e = \frac{(\text{Row total})(\text{Column total})}{(\text{Grand total})}$
The null hypothesis is rejected if: $\chi^2 > \chi^2_{a,(r-1)(c-1)}$; $\sum\left[\frac{(f_o - f_e)^2}{f_e}\right] > \chi^2_{a,(r-1)(c-1)}$

Data were collected from the Cockpit Voice Recorder Database. The three cases concerned accidents involving Ethiopian Airlines ET-302, Southwest 1380, and Air France 447. Each has a cockpit voice recorder transcript. The Appendix Tables A1 to A3 report the analysis results of team resilience for the three respective accidents. Given the three case studies, there are 4 tests, including three tests for the three cases and a fourth one using the data pooled from all the three cases together.

Tables A1 to A3 show the actions and communication between the team members through the four stages of accident response process, Observe, Orient, Decide, and Act. The first stage – *Observe* – with 48 total counts has most extensive information compared with the others, followed by *Act* with 40 counts, *Orient* with 35 counts, and *Decide* with 27 counts.

On the other hand, Sharing and Communication appear to have most counts, 46 and 43 respectively. This is expected due to the fact that the reports provide communication related information. Leadership and Coordination have the least number of counts of 29 and 32 items respectively. Again, this indicates that factors with a small number of counts were least observable.

It is important to note that factors with a small number of counts were least observable. Thus, the analysis must be done with care and findings are only for references. Yet, there was a high level of complexity involved in the four stages of response process and not all the details were revealed or captured by the report.

Table 2 reports the analysis result of pooled data. Across all the three cases, there was insufficient evidence to reject any relationship between team factors – Sharing, Communication, Leadership, and Coordination – and the four stages of the response process

– Observe, Orient, Decide, and Act. The values of the χ^2 statistics for the three cases are: 6.18, 4.93, and 2.22 respectively. In all cases, the p_{value} is larger even than the 10% significant level, showing no significance. The result of the pooled data analysis has χ^2 of 7.31 and p_{value} of 0.605 (also showing no significance). This confirms no relationship between the team factors and the response stages.

Table 2: Pooled analysis result

	Response stages								
Team factor	**Observe**		**Orient**		**Decide**		**Act**		**Total**
Sharing	13	14.7	9	10.7	9	8.28	15	12.3	**46**
Communication	18	13.8	13	10.0	5	7.74	7	11.5	**43**
Leadership	9	9.28	6	6.77	6	5.22	8	7.73	**29**
Coordination	8	10.2	7	7.47	7	5.76	10	8.53	**32**
Total	**48**	**48**	**35**	**35**	**27**	**27**	**40**	**40**	**150**
Test result	χ^2 =7.31; p_{value}=0.605								

5. Conclusion

The paper expanded knowledge in the team resilience in aviation, as an understudies domain. We reviewed the role of team performance and resilience in emergency response in the aviation domain, where there is a limited amount of studies. We emphasized the importance of organizational aspects to such emergency circumstances in planes. We adopted the OODA LOOP analytic framework from other domains of resilience (e.g. maritime) to classify the aspects significant to team resilience in air transportation accidents applying former developments in this field. We gave an overview on the framework and utilized it to discuss and evaluate the team resilience and performance in three aircraft accidents, related to Ethiopian Airlines 302, Southwest 1380, and Air France 447. The analysis of the cases showed that interaction and organization are some of the crucial factors in onboard teams' emergency response and it is what grounds sternness in the aftereffects from aviation accidents in many occurrences. We were able to trail that back to training ethics and excellence and its effectiveness in educating onboard team performance.

Our findings are an initial step in understanding the role of team resilience in air accidents and how its improvement can reduce air accidents (or their severity). We demonstrated the importance of cockpit resource management training for better onboard team performance, as well as unity and culture. Those findings can serve to improve training of cockpit personnel to improve their accident avoidance skills related to better team resilieicen.

References

Akselsson, R., Koornneef, F., Stewart, S. and Ward, M., 2009. Resilience safety culture in aviation organisations. HILAS (Human Integration into the Lifecycle of Aviation Systems) 2009: Chapter 2; draft version.

Alliger, G. M., Cerasoli, C. P., Tannenbaum, S. I., & Vessey, W. B. 2015. Team resilience: How teams flourish under pressure. Organizational Dynamics, 44(3), pp. 176–184

Amaral, A., Fernandes, G. and Varajão, J., 2015. Identifying useful actions to improve team resilience in information systems projects. Procedia Computer Science, 64, pp.1182-1189.

Boyd, J.R., 1996. The essence of winning and losing. Unpublished lecture notes, 12(23), pp.123-125.

Burgoon, J.K., 1993. Interpersonal expectations, expectancy violations, and emotional communication. Journal of Language and Social Psychology, 12(1-2), pp.30-48.

Chapman, M.T., Lines, R.L., Crane, M., Ducker, K.J., Ntoumanis, N., Peeling, P., Parker, S.K., Quested, E., Temby, P., Thøgersen-Ntoumani, C. and Gucciardi, D.F., 2020. Team resilience: A scoping review of conceptual and empirical work. Work & Stress, 34(1), pp.57-81.

Chialastri, A. and Pozzi, S., 2008, September. Resilience in the aviation system. In International Conference on Computer Safety, Reliability, and Security (pp. 86-98). Springer, Berlin, Heidelberg.

Dimas, I.D., Rebelo, T., Lourenço, P.R. and Pessoa, C.I.P., 2018. Bouncing back from setbacks: On the mediating role of team resilience in the relationship between transformational leadership and team effectiveness. The Journal of Psychology, 152(6), pp.358-372.

Dyer, J.L., 1984. Team research and team training: A state-of-the-art review. Human factors review, 26, pp.285-323.

Entin, E.E. and Serfaty, D., 1999. Adaptive team coordination. Human factors, 41(2), pp.312-325.

Eurocontrol, 2009. White Paper on Resilience Engineering for ATM. Report of the Project Resilience Engineering for ATM.

Gersick, C.J. and Hackman, J.R., 1990. Habitual routines in task-performing groups. Organizational behavior and human decision processes, 47(1), pp.65-97.

Gomes, J.O., Borges, M.R., Huber, G.J. and Carvalho, P.V.R., 2014. Analysis of the resilience of team performance during a nuclear emergency response exercise. Applied ergonomics, 45(3), pp.780-788.

Gorgulu, R., Senel, E., Adilogulları, İ. and Yildiz, M., 2018. An adaptation study of measurement properties for the characteristics of resilience in sports team inventory. *Education Sciences*, *8*(3), p.139.

Gucciardi, D.F., Crane, M., Ntoumanis, N., Parker, S.K., Thøgersen-Ntoumani, C., Ducker, K.J., Peeling, P., Chapman, M.T., Quested, E. and Temby, P., 2018. The emergence of team resilience: A multilevel conceptual model of facilitating factors. Journal of Occupational and Organizational Psychology, 91(4), pp.729-768.

Hedlund, J., Ilgen, D.R. and Hollenbeck, J.R., 1998. Decision accuracy in computer-mediated versus face-to-face decision-making teams. Organizational Behavior and Human Decision Processes, 76(1), pp.30-47.

Hesse, M., Kallus, W. and Kolodej, C., 2013, June. Assessing behaviour towards organizational resilience in aviation. In 5th REA Symposium managing tradeoffs (pp. 67-74).

Johansson, B.J., van Laere, J. and Berggren, P., 2018. Evaluating Team Resilience in Simulator-Based Crisis Management Training. In The 15th International Conference on

Information Systems for Crisis Response and Management (ISCRAM), Rochester, NY, USA, May 20-23, 2018 (pp. 914-923). Rochester Institute of Technology.
Jung, D.I., Bass, B.M. and Sosik, J.J., 1995. Bridging leadership and culture: A theoretical consideration of transformational leadership and collectivistic cultures. Journal of Leadership Studies, 2(4), pp.3-18.
Kim, Y.J., Engel, D., Woolley, A.W., Lin, J.Y.T., McArthur, N. and Malone, T.W., 2017, February. What makes a strong team? Using collective intelligence to predict team performance in League of Legends. In Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (pp. 2316-2329).
King, D.D., Newman, A. and Luthans, F., 2016. Not if, but when we need resilience in the workplace. Journal of organizational behavior, 37(5), pp.782-786.
Knapp, R., 2010. Collective (team) learning process models: A conceptual review. Human Resource Development Review, 9(3), pp.285-299.
Kozlowski, S.W. and Ilgen, D.R., 2006. Enhancing the effectiveness of work groups and teams. Psychological science in the public interest, 7(3), pp.77-124.
Kozlowski, S.W. and Ilgen, D.R., 2006. Enhancing the effectiveness of work groups and teams. Psychological science in the public interest, 7(3), pp.77-124.
Lengnick-Hall, C.A., Beck, T.E. and Lengnick-Hall, M.L., 2011. Developing a capacity for organizational resilience through strategic human resource management. Human resource management review, 21(3), pp.243-255.
Linthicum, D.W., 2012. Crossing the River: A Conceptual Framework for Response to Chaos. NAVAL POSTGRADUATE SCHOOL MONTEREY CA.
Lionel, ST 2015. Leveraging social capital for resilience through community teams. RUSI Journal, vol. 160, no. 6, pp. 68-73.
Lundberg, J. and Johansson, B.J., 2015. Systemic resilience model. Reliability Engineering & System Safety, 141, pp.22-32.
McCray, J., Palmer, A. and Chmiel, N., 2016. Building resilience in health and social care teams. Personnel Review, Vol. 45 No. 6, pp. 1132-1155.
Mjelde, F.V., Smith, K., Lunde, P. and Espevik, R., 2016. Military teams–A demand for resilience. Work, 54(2), pp.283-294.
Morgan, P.B., Fletcher, D. and Sarkar, M., 2013. Defining and characterizing team resilience in elite sport. Psychology of Sport and Exercise, 14(4), pp.549-559.
Morgan, P.B., Fletcher, D. and Sarkar, M., 2015. Understanding team resilience in the world's best athletes: A case study of a rugby union World Cup winning team. Psychology of sport and exercise, 16, pp.91-100.
Morgan, P.B., Fletcher, D. and Sarkar, M., 2017. Recent developments in team resilience research in elite sport. Current Opinion in Psychology, 16, pp.159-164.
Nguyen, Hong-Oanh, Gamage, S., Beckett, A., Turner, P., Taskhiri, M., and Natalia Nikolova. 2019. "Team Resilience in Maritime Emergency Response: Analytical Framework and Implications from Accident Report Analysis." The International Association of Maritime Universities (IAMU) Conference. 340-347.
Owen, D., Gill, S., Courtney, H., McDonald, N., Liston, P. and Carrera, M., 2017. Exploring resilience in aviation and maritime transport–and how human factors can help. The Resilience Shift, p.2018.
Page, S.E., 2008. The difference: How the power of diversity creates better groups, firms, schools, and societies-new edition. Princeton University Press.
Rodríguez-Sánchez, A. and Vera Perea, M., 2015. The secret of organisation success: A revision on organisational and team resilience.
Sauer, J., Felsing, T., Franke, H. and Rüttinger, B., 2006. Cognitive diversity and team performance in a complex multiple task environment. Ergonomics, 49(10), pp.934-954.

Sommer, SA, Howell, JM & Hadley, CN 2016. Keeping positive and building strength: The role of affect and team leadership in developing resilience during an organizational crisis. Group and Organization Management, vol. 41, no. 2, pp. 172-202.
Stachowski, A.A., Kaplan, S.A. and Waller, M.J., 2009. The benefits of flexible team interaction during crises. Journal of Applied Psychology, 94(6), p.1536.
Stephens, J.P., Heaphy, E.D., Carmeli, A., Spreitzer, G.M. and Dutton, J.E., 2013. Relationship quality and virtuousness: Emotional carrying capacity as a source of individual and team resilience. The Journal of Applied Behavioral Science, 49(1), pp.13-41.
Stout, R.J., Cannon-Bowers, J.A., Salas, E. and Milanovich, D.M., 1999. Planning shared mental models, and coordinated performance: An empirical link is established. Human Factors, 41(1), pp.61-71.
Sutcliffe, K.M. and Vogus, T.J., 2003. Organizing for resilience. Positive organizational scholarship: Foundations of a new discipline, 94, p.110.
Von Lubitz, D.K., Beakley, J.E. and Patricelli, F., 2008. 'All hazards approach'to disaster management: the role of information and knowledge management, Boyd's OODA Loop, and network-centricity. Disasters, 32(4), pp.561-585.
Waller, M.A., 2001. Resilience in ecosystemic context: Evolution of the concept. American journal of orthopsychiatry, 71(3), pp.290-297.
Woltjer, R., Pinska-Chauvin, E., Laursen, T. and Josefsson, B., 2015. Towards understanding work-as-done in air traffic management safety assessment and design. Reliability Engineering & System Safety, 141, pp.115-130.
Yu, T., Sengul, M. and Lester, R.H., 2008. Misery loves company: The spread of negative impacts resulting from an organizational crisis. Academy of Management Review, 33(2), pp.452-472.

APPENDIX: Case study analysis

Table A1. Ethiopian Airlines 302

Team	Response process			
	Observe	Orient	Decide	Act
Sharing: sharing team value and work, allocating resources, caring each other safety, etc.	▪ The Captain advised the First-Officer to contact radar. ▪ Captain requested flaps up ▪ Captain asked the First-Officer to request to maintain runway heading. ▪ The Captain asked the First Officer to pitch up together and said that pitch is not enough. 4	▪ The Captain advised again the First-Officer to request to maintain runway heading and that they are having flight control problems. 1	▪ The First-Officer reported to ATC that they were unable to maintain SHALA IA and requested runway heading 1	▪ First Officer reported SHALA 2A departure crossing 8400 ft and climbing FL 320. ▪ First Officer acknowledged ▪ Approved by ATC 3
Communication: exchanging information, verbally, using technologies, etc.	▪ The First Officer called out Master Caution Anti-Ice on CVR. ▪ Captain called out "Command" ▪ Radar controller identified ET-302. ▪ The stabilizer trim cutout switches were in the "cutout" position ▪ The Captain instructed the First Officer to advise ATC ▪ Both pilots called out "left alpha vane". ▪ 8	▪ Instructed to climb FL 340 and when able right turns direct to RUDOL ▪ Captain called out three times "Pull-up" ▪ That they would like to maintain 14,000 ft and they have flight control problem. 3	▪ First-Officer requested ATC to maintain 14,000 ft and reported that they are having flight control problem 1	▪ The First-Officer acknowledged. ▪ ATC approved. 3
Leadership: Vision, decision making process, participation of team members, etc.	▪ Three Ground Proximity Warning System (GPWS) "DON'T SINK" alerts occurred. ▪ The Captain asked the First-Officer if the trim is functional. 2	▪ The First-Officer has replied that the trim was not working and asked if he could try it manually. 1	▪ The Captain told him to try. 1	▪ The Captain advised the First-Officer to trim up with him. ▪ The First-Officer replied that it is not working. 2

Coordination: Planning, timing, organising, monitoring the progress, etc.	▪ Manual electric trim in the ANU direction was recorded and the stabilizer reversed moving in the ANU direction and then the trim reached 2.3 units ▪ The Captain asked and the First-Officer requested radar control a vector to return 2	▪ The First-Officer called out "stab trim cut-out" two times. ▪ ATC instructed ET-302 to turn right heading 260 degrees and the First-Officer acknowledged. 2	▪ Captain agreed ▪ The selected heading was changed to 262 degrees. 2	▪ First Officer confirmed stab trim cut-out. ▪ ATC approved. 2
Test result	Chi-square statistic: 6.14 P-value: 0.726			

Table A2. Southwest 1380

Team	Response process			
	Observe	Orient	Decide	Act
Sharing: sharing team value and work, allocating resources, caring each other safety, etc.	▪ there was a "gray puff of smoke" and a sudden change in cabin pressure ▪ Three flight attendants were assigned to the flight ▪ As they moved toward the mid-cabin, 3	▪ All four reported that they heard a loud sound and felt a vibration. ▪ they found the passenger in row 14 partially out of the window 2	▪ began moving through the cabin to assist passengers with their masks. ▪ attempted to pull her inside. 2	▪ They donned their oxygen masks, ▪ The flight attendants retrieved portable oxygen bottles ▪ They were able to retrieve her with the help of two passengers, and other passengers erformed cardiopulmonary resuscitation. 3
Communication: exchanging information, verbally, using technologies, etc.	▪ The flight crew stated that the departure and climb from LaGuardia were normal with no indications of any problems ▪ They reported that the aircraft yawed with several cockpit alarms	▪ she first requested the nearest airport	▪ but quickly decided on Philadelphia.	▪ The controller provided vectors to the airport with no delay.

	▪ The flight crew reported that the aircraft exhibited handling difficulties throughout the remainder of the flight. ▪ The flight crew reported initial communications difficulties 4	1	1	1
Leadership: Vision, decision making process, participation of team members, etc.	▪ The captain took over flying duties ▪ The captain initially was planning on a long final approach to make sure they completed all the checklists 2	▪ The captain requested a diversion from the air traffic controller ▪ but when they learned of the passenger injuries 2	▪ she decided to shorten the approach 1	▪ expedite landing. 1
Coordination: Planning, timing, organising, monitoring the progress, etc.	▪ the first officer was flying, and the captain was monitoring. 1	▪ there was a "gray puff of smoke" and a sudden change in cabin pressure. ▪ aircraft rolled left to about 40 degrees 2	▪ before the flight crew was able to counter the roll with control inputs. 1	▪ They donned their oxygen masks, ▪ the first officer began a descent. ▪ removed from the aircraft alive 3
Test result	Chi-square statistic: 4.93 P-value: 0.840			

Table A3. Air France 447

Team	Response process			
	Observe	Orient	Decide	Act
Sharing: sharing team value and work, allocating resources, caring each other safety, etc.	▪ Let's go for the anti-icing system. It's better than nothing. ▪ Let's go for the anti-icing system. It's better than nothing. ▪ Robert has no idea that, despite their conversation about descending. ▪ The men are utterly failing to engage in an important process known as crew resource management, or CRM. ▪ We've totally lost control of the plane. ▪ As the plane is buffeted by turbulence. 6	▪ We seem to be at the end of the cloud layer, it might be okay. ▪ Pay attention to your speed. ▪ It is not clear to either one of them who is responsible for what, and who is doing what. ▪ We don't understand at all ▪ What do you think? ▪ The captain urges Bonin to level the wings 6	▪ You can possibly pull it a little to the left. ▪ okay, I'm descending. ▪ What should we do? ▪ Robert tries to take back the controls, and pushes forward on the stick, but the plane is in "dual input" mode. ▪ At last, Bonin tells the others 5	▪ We're agreed that we're in manual ▪ Here we go, we're descending. ▪ Bonin has continued to pull back on the side stick. ▪ They are failing, essentially, to cooperate. ▪ Left seat taking control! ▪ We've tried everything ▪ Inputs with those of Bonin, who continues to pull back. ▪ The crucial fact whose import he has so grievously failed to understand himself. ▪ Bonin yields the controls, and Robert finally puts the nose dow 9
Communication: exchanging information, verbally, using technologies, etc.	▪ The pilot warned the cabin crew that they were about to enter an area of turbulence. ▪ I'll call you back as soon as we're out of it. ▪ There's no good speed indication. ▪ The stall warning continues to blare. ▪ No one mentions the word "stall." ▪ Damn it, we're going to crash. 6	▪ Yes, let's call them in the back, to let them know. ▪ What the hell are you doing? ▪ With no hint of understanding the nature of their problem. ▪ The men briefly discuss, incredibly 4	▪ You'll want to take care. ▪ I think that's not a bad idea. ▪ Before agreeing that they are indeed descending. 3	▪ Give your friends a heads-up ▪ the three pilots discuss the situation ▪ I have the controls. 3
Leadership: Vision, decision making process, participation of	▪ After having attended the briefing between the two co-pilots. ▪ This is a natural result of having two co-pilots flying the plane.	▪ He, too, seems unaware of the fact that the plane is now stalled. ▪ He almost certainly would have understood, as a pilot with many hours flying light airplanes, the	▪ The captain had sent one of the co-pilots for the first rest period. ▪ He woke the second pilot.	▪ Intention of taking the second break himself. ▪ The captain left the cockpit to rest. ▪ Pulls back on the stick as well.

team members, etc.	▪ When you have a captain and a first officer in the cockpit, it's clear who's in charge. ▪ The captain returns to the cockpit. 4	insanity of pulling back on the controls while stalled. ▪ No, no, no… Don't climb… no, no. 3	▪ One who seems to have a somewhat better grasp of the situation. ▪ The captain of the flight makes no attempt [illegible] physically take co[illegible] the airplane. 4	▪ He takes a seat behind the other two pilots. 5
Coordination: Planning, timing, organising, monitoring the progress, etc.	▪ Turbulence penetration speed. ▪ The aircraft's stall warning sounded briefly twice due to the angle of attack tolerance being exceeded. ▪ Icing event had lasted for just over a minute ▪ The turbulence, the strange electrical phenomena. ▪ Plane has barely enough forward speed for the controls to be effective. 5	▪ The aircraft started to roll to the right due to turbulence. ▪ His colleague's failure to route around the potentially dangerous storm. ▪ Bonin reacts irrationally. 3	▪ The pilots turned the aircraft slightly to the left. ▪ He pulls back on the side stick to put the airplane into a steep climb. ▪ He is holding the stick all the way back. ▪ Bonin once again takes back the controls. 4	▪ Decreased its speed ▪ The pilot reacted by deflecting his side-stick to the left. ▪ The pilot continued making nose-up inputs. ▪ Almost as soon as Bonin pulls up into a climb, the plane's computer reacts. ▪ Pulls his side stick all the way back. 5
Test result	Chi-square statistic: 2.26 P-value: 0.987			